Name: _____

SCH OA1
Thermodynamics Test

1. For each of the following, label with a + for in increase in potential energy or a - for a decrease in potential energy. Be careful. One-half mark will be deducted for each incorrect response.

a) + The formation of ethyne from its component elements.

b) − Sand is used to make glass.

c) − Calcium carbonate is formed by the addition of carbon dioxide to calcium oxide.

d) + Growth of a Western Red Cedar (i.e. humongous tree).

e) − Cellular respiration.

f) − Formation of a cloud.

g) − Sublimation of $H_2O(g)$ to $H_2O(s)$.

h) − Reaction of propane with oxygen.

i) + Reduction of tin (IV) oxide to tin (II) oxide.

j) + Conversion of glucose to hexane.

9

2. Please write the combustion reaction of hexane ($C_6H_{14}(l)$) as thermodynamic equation and as a thermochemical equation. The heat of combustion of hexane is -4162.9 kJ

$C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l) \quad \Delta H = -4162.9\ kJ$

$C_6H_{14}(l) + \frac{19}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(l) + 4162.9\ kJ$

9

3. Calculate the heat of reaction for:

$$2\,Al(NO_3)_3(aq) + 3(NH_4)_2SO_4(aq) \Rightarrow Al_2(SO_4)_3(s) + 6\,NH_4NO_3(s)$$ ✓

Using the following heats of formation and heats of formation listed in your text.

(9)

$\Delta H^\circ_{Al(NO3)3(aq)} = -273.65$ kcal
$\Delta H^\circ_{(NH4)2SO4(aq)} = -281.86$ kcal
$\Delta H^\circ_{Al2(SO4)3(s)} = -820.98$ kcal

$\Delta H^\circ_{NH_4NO_3(s)} = -365.6$ kJ
$= -87.38$ kcal ✓

Please note that this is not a Hess' Law problem.

$$\Delta H = [\Delta H^\circ_{al_2(SO_4)_3(s)} + 6\,\Delta H^\circ_{NH_4NO_3(s)}] - [2\,\Delta H^\circ_{al(NO_3)_3(aq)} + 3\,\Delta H^\circ_{(NH_4)_2SO_4(aq)}]$$ ✓

$$\Delta H = [-820.98\,kcal + 6(-87.38\,kcal)] - [2(-273.65\,kcal) + 3(-281.86\,kcal)]$$

$\Delta H = 47.62$ kcal ✓

or

199.24 kJ

4. Determine the final temperature if 70.594 kJ of heat is added to 125 g of ice at 0°C. Useful information can be found in your text on page 307 and of course page 799.

Find heat absorbed by change of state ($H_2O(s)$ @ 0°C → $H_2O(l)$ @ 0°C)

(9)

$Q = L_F\,m$ ✓

$$Q = \left(\frac{6.03\,kJ}{1mol} \times \frac{1mol}{18.02g}\right) \times 125g$$ ✓

$Q = 41.829$ kJ ✓

Find heat not used to cause change of state

$70.594\,kJ - 41.829\,kJ = 28.765\,kJ$ ✓

Use remaining heat to warm water

$Q = 28.765\,kJ \rightarrow 28765\,J$
$m = 125\,g$
$c = 4.184\,J/g°C$
$\Delta T = ?$

$$\Delta T = \frac{Q}{mc}$$ ✓

$$\Delta T = \frac{28765\,J}{125g \times 4.184\,J/g°C}$$

$\Delta T = 55.00°C$ ✓

∴ the water warms by 55.00°C from 0°C to 55.00°C

5. Determine the mass of propane that must be combusted to warm 160 L of water from 15 °C to 52 °C. You may use any heats of formation from the textbook that you like.

(9)

$Q = ?$

$m = 160\,L \rightarrow 160000\,g$

$c = 4.184\,J/g°C$

$\Delta T = 52°C - 15°C = 37°C$

$Q = mc\Delta T$ ✓

$Q = 160000\,g \times 4.184\,J/g°C \times 37°C$

$Q = 24769280\,J$ ✓

$Q = 24769\,kJ$ ✓

↑ this is the heat energy required

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell) \quad \Delta H = ?$ ✓

$\Delta H = [3\Delta H^\circ_{CO_2(g)} + 4\Delta H^\circ_{H_2O(\ell)}] - [\Delta H^\circ_{C_3H_8(g)} + 5\Delta H^\circ_{O_2(g)}]$ ✓

$\Delta H = [3(-393.5\,kJ) + 4(-285.8\,kJ)] - [(-104.7\,kJ) + 5(0)]$

$\Delta H = -2219.0\,kJ$ ✓

$\Delta H = -Q$

$Q = 2219.0\,kJ/mol\ C_3H_8$ ✓

↑ Heat released per mol of C_3H_8 combustion

$$24769\,kJ \times \frac{1\,mol\ C_3H_8}{2219.0\,kJ} \times \frac{44.11\,g\ C_3H_8}{1\,mol\ C_3H_8} = 492.37\,g\ C_3H_8$$

✓ ✓ ✓ ✓

6. If 50 L of water is warmed by 11.469 °C by the combustion of 50 g of decane, determine the heat of formation of decane. This is not a Hess' Law problem. You may use any heats of formation that you wish from the textbook.

(9)

$Q = ?$

$m = 50\,L \Rightarrow 50\,000\,g$

$c = 4.184\ J/g°C$

$\Delta T = 11.469°C$

$Q = mc\Delta T$ ✓

$Q = 50\,000\,g \times 4.184\,J/g°C \times 11.469°C$

$Q = 2399314\,J$ ✓

$Q = 2399.31\,kJ$ ✓

$$\frac{2399.31\,kJ}{50\,g\ C_{10}H_{22}} \times \frac{142.32\,g\ C_{10}H_{22}}{1\,mol\ C_{10}H_{22}} = 6829.41\,kJ/mol\ C_{10}H_{22}$$ ✓ ✓ ✓

$\Delta H = -Q$ ✓

$\Delta H = -6829.41\,kJ/mol\ C_{10}H_{22}$

$\therefore C_{10}H_{22}(\ell) + \frac{31}{2}O_2(g) \rightarrow 10CO_2(g) + 11H_2O(\ell)$ ✓ $\Delta H = -6829.41\,kJ$

$\Delta H = [10\Delta H^\circ_{CO_2(g)} + 11\Delta H^\circ_{H_2O(\ell)}] - [\Delta H^\circ_{C_{10}H_{22}(\ell)} + \frac{31}{2}\Delta H^\circ_{O_2(g)}]$ ✓ ✓✓

$-6829.41\,kJ = [10(-393.5\,kJ) + 11(-285.8\,kJ)] - [\Delta H^\circ_{C_{10}H_{22}(\ell)} + \frac{31}{2}(0)]$

$\therefore \Delta H^\circ_{C_{10}H_{22}} = -249.39\,kJ$ ✓

7. Use Hess' Law to find the heat of formation of ethane (C_2H_6) given:

① $C_2H_6(g) + \frac{1}{2}Cl_2(g) \Rightarrow C_2H_5Cl(g) + \frac{1}{2}H_2(g)$ $\Delta H° = 8.6$ kJ

② The heat of combustion of ethanol is -1409.2 kJ.

③ $C_2H_5Cl(g) + H_2O(g) \Rightarrow C_2H_5OH(l) + HCl(g)$ $\Delta H° = 33.5$ kJ

④ The heat of formation (and reaction thereof) for carbon dioxide gas.

⑤ The heat of formation (and reaction thereof) for water ~~vapour.~~

⑥ The heat of formation (and reaction thereof) for hydrogen chloride gas.

See text book for heats of formation and the answer!!

find $2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$ ✓

Given

① $C_2H_6(g) + \frac{1}{2}Cl_2(g) \rightarrow C_2H_5Cl + \frac{1}{2}H_2(g)$ $\Delta H = 8.6$ kJ

② $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ ✓ $\Delta H = -1409.2$ kJ

③ $C_2H_5Cl(g) + H_2O(g) \rightarrow C_2H_5OH(l) + HCl(g)$ $\Delta H = 33.5$ kJ

④ $C(s) + O_2(g) \rightarrow CO_2(g)$ ✓ $\Delta H = -393.5$ kJ

⑤ $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ ✓ $\Delta H = -285.8$ kJ

⑥ $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ ✓ $\Delta H = -92.3$ kJ

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rev ✓ ① $C_2H_5Cl(g) + \frac{1}{2}H_2(g) \rightarrow C_2H_6(g) + \frac{1}{2}Cl_2(g)$ $\Delta H = -8.6$ kJ

rev ✓ ③ $C_2H_5OH(l) + HCl(g) \rightarrow C_2H_5Cl(g) + H_2O(l)$ $\Delta H = -33.5$ kJ

rev ✓ ② $2CO_2(g) + 3H_2O(l) \rightarrow C_2H_5OH(l) + 3O_2(g)$ $\Delta H = 1409.2$ kJ

⑥ $\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g)$ $\Delta H = -92.3$ kJ

✓2 × ④ $2C(s) + 2O_2(g) \rightarrow 2CO_2(g)$ $\Delta H = -787.0$ kJ

✓2 × ⑤ $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -571.6$ kJ

$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$ ✓ -83.8 kJ ✓